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## Building Clouds with OpenNebula: A Grid Computing Perspective

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# Building Clouds with OpenNebula: A Grid Computing Perspective

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- Provide an overview of Cloud Computing
- Describe how Clouds can help Grids
- Experiences using Clouds and Grids
- Hands on: Using a OpenNebula Cloud

# Cloud Computing in a Nutshell

## Software as a Service

On-demand access to any application

**End-user**  
(does not care about hw or sw)



facebook

## Platform as a Service

Platform for building and delivering web applications

**Developer**  
(no managing of the underlying hw & sw layers)



Windows Azure

force.com  
platform as a service

## Infrastructure as a Service



Physical Infrastructure

Delivery of a *raw* computer infrastructure

**System Administrator**  
(complete management of the computer infrastructure)

GO GRID

flexiscale™

amazon  
web services™

# The Public IaaS Cloud

- **Simple Web Interface**
- **Raw *Infrastructure* Resources**
  - Total control of the resources
  - Capacity leased in the form of Vms
  - Complete Service-HW decoupling
- **Pay-as-you-go (On-demand access)**
  - A single user can not get all the resources
  - Multi-tenancy
- **Elastic & “*infinite*” Capacity**

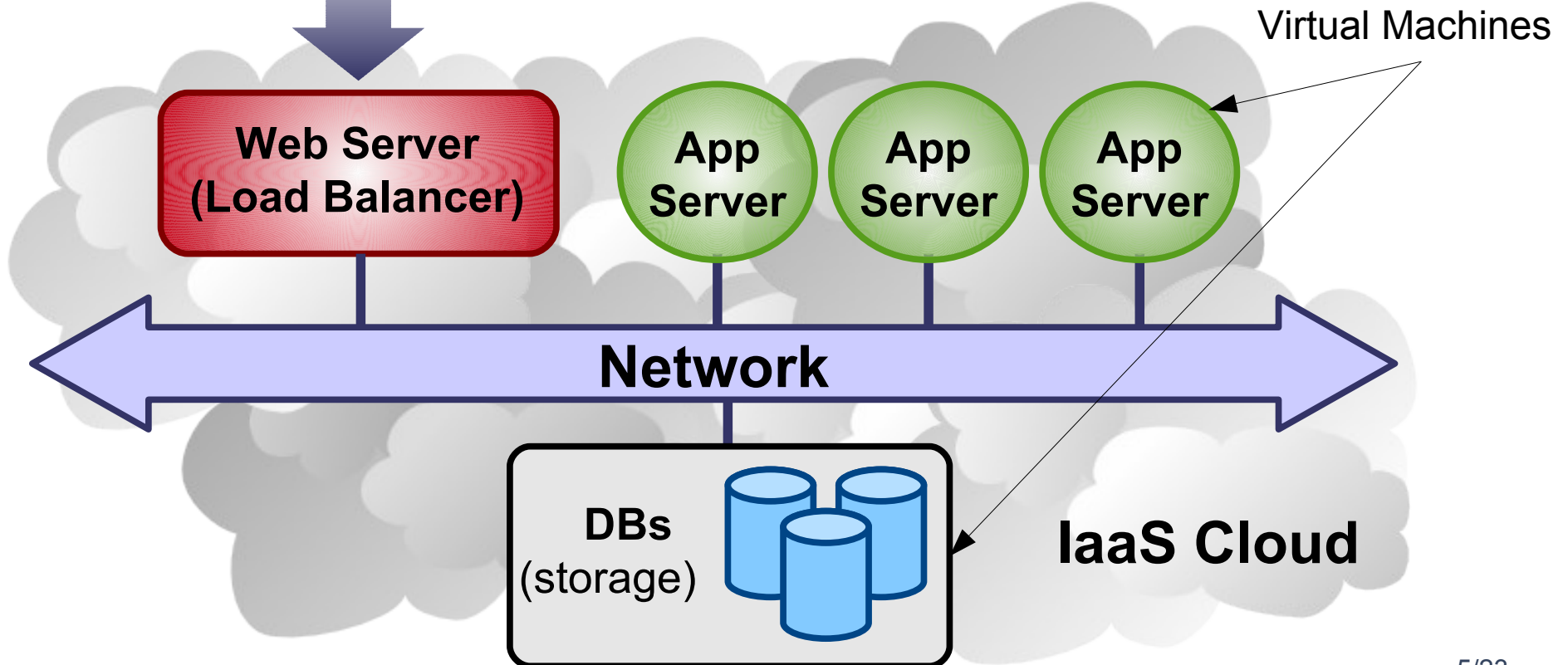
# Using a Public IaaS Cloud



**Service End-Users**

## Total control of service layout

- Resources allocated
- Software Stack
- Type & Number of components
- Service Elasticity



# The Private IaaS Cloud

## A “Public Cloud behind the firewall”

- Security concerns
- Flexible management (consolidation, adaptation, provisioning...)

## VMs are great!!... (*the BUT's*)

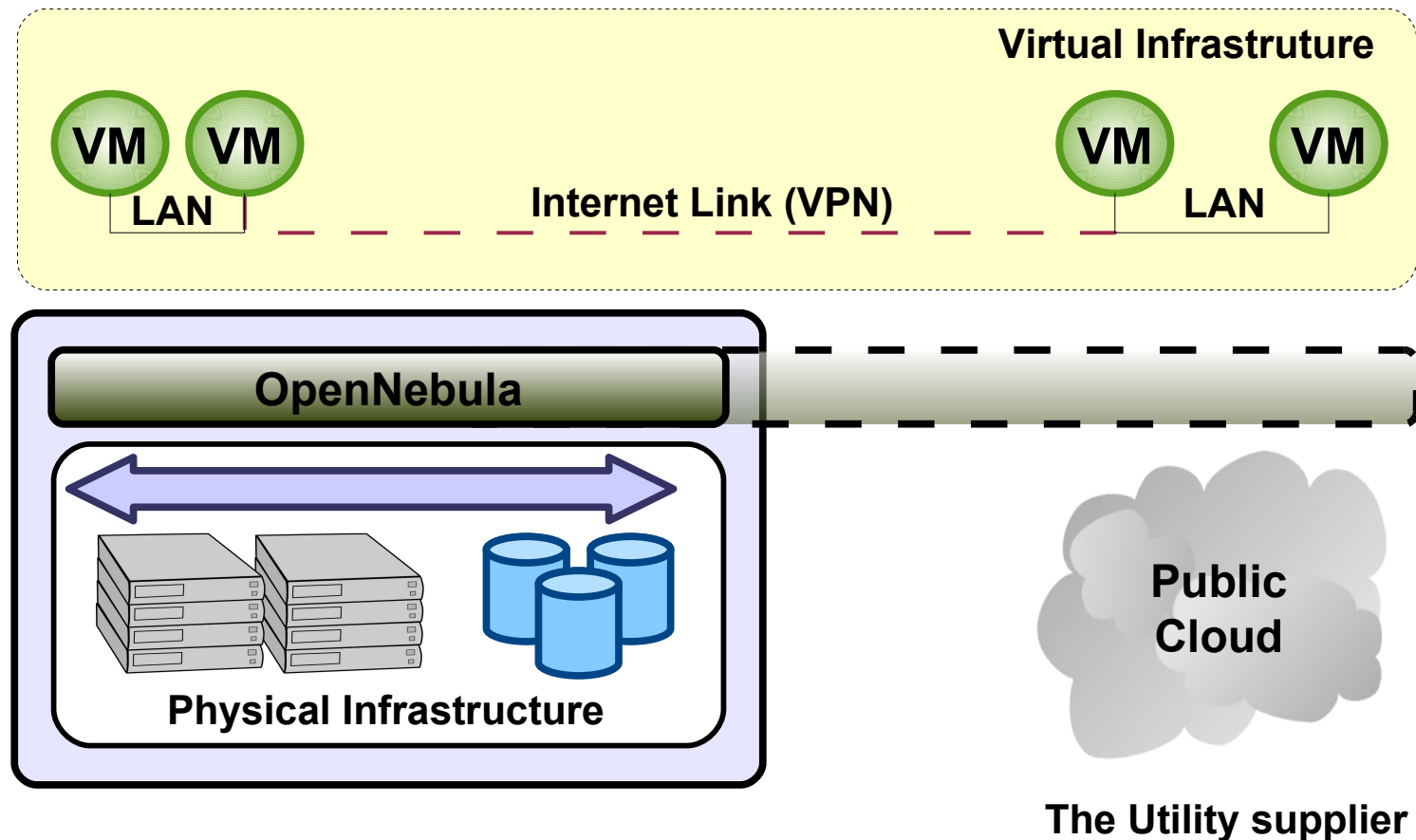
- Where did/do I put my VM? (*scheduling & monitoring*)
- How do I provision a new cluster node? (*clone & context*)
- What MAC addresses are available? (*networking*)

## Cloud Management Layer (e.g. OpenNebula)

- Provides a *uniform view* of the physical resource pool
- *Life-cycle management* and monitoring of VM
- *Integrates* Image, Network and Virtualization

# The Hybrid IaaS Cloud

- Supplement the capacity of the local infrastructure
- Transparent access to the resulting hybrid cloud
- Utility Computing dream made a reality!



# What is OpenNebula?



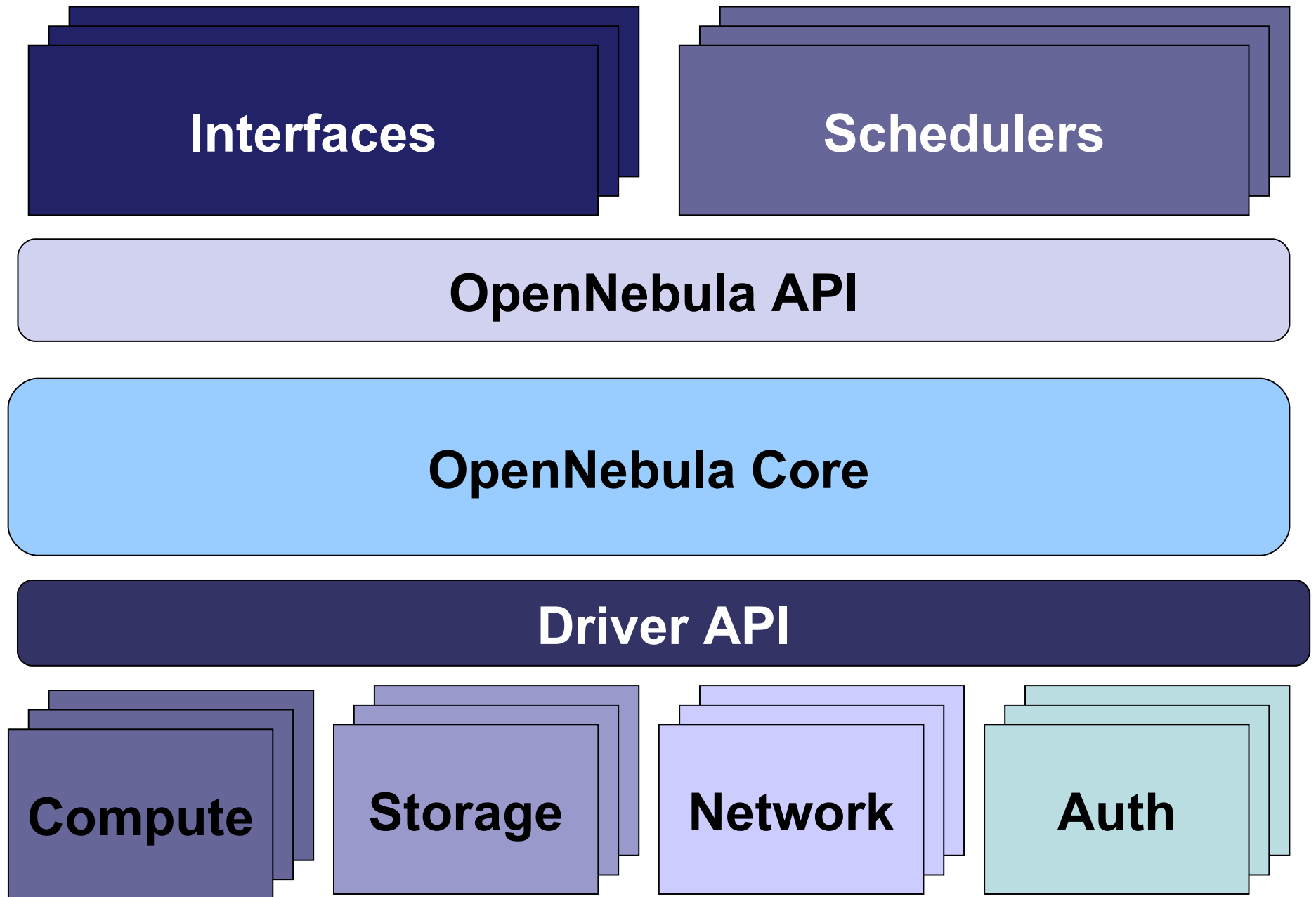
**OpenNebula is a standard-based open-source toolkit to build private, public and hybrid clouds**

## **Design Philosophy**

- One solution can not fit all data-center and user requirements and constraints
- Open, Flexible and extensible architecture that allows multiple components to be orchestrated
- Provide basic components, but allow them to be easily replaceable by others



# What is OpenNebula?



# Building Clouds with OpenNebula: A Grid Computing Perspective

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# Current Grid Infrastructures...

- High degree of heterogeneity (software & hardware)
- High operational costs
- Isolate and partition resources contributed to the Grid
- Specific environment requirements for different Vos
- Users simply do not feel like adopting our execution models (*pilot jobs...*)

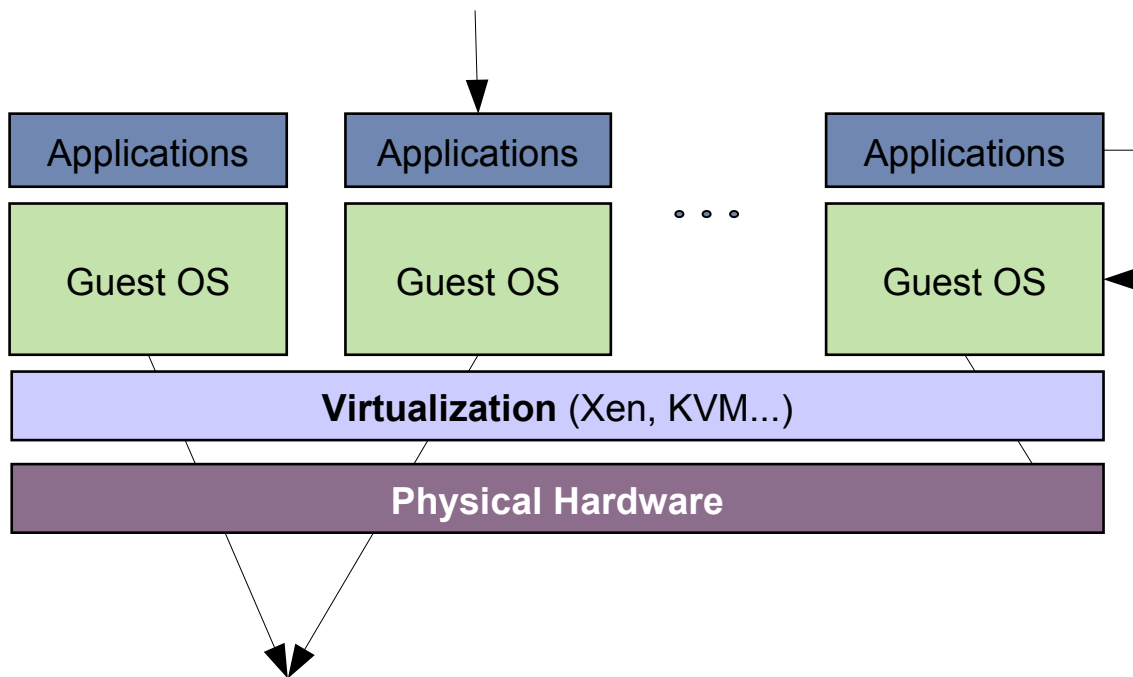


Grids are difficult to maintain, operate and use

# Grids, Clouds... and Virtual Machines

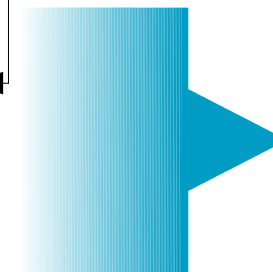
- A VM is an isolated runtime environment (guest OS and apps)
- Hypervisors: Full Virtualized, para-virtualization, HW Virtualization

## Execution of **legacy applications**



Domains are **isolated**

Natural way to deal with the **heterogeneity**

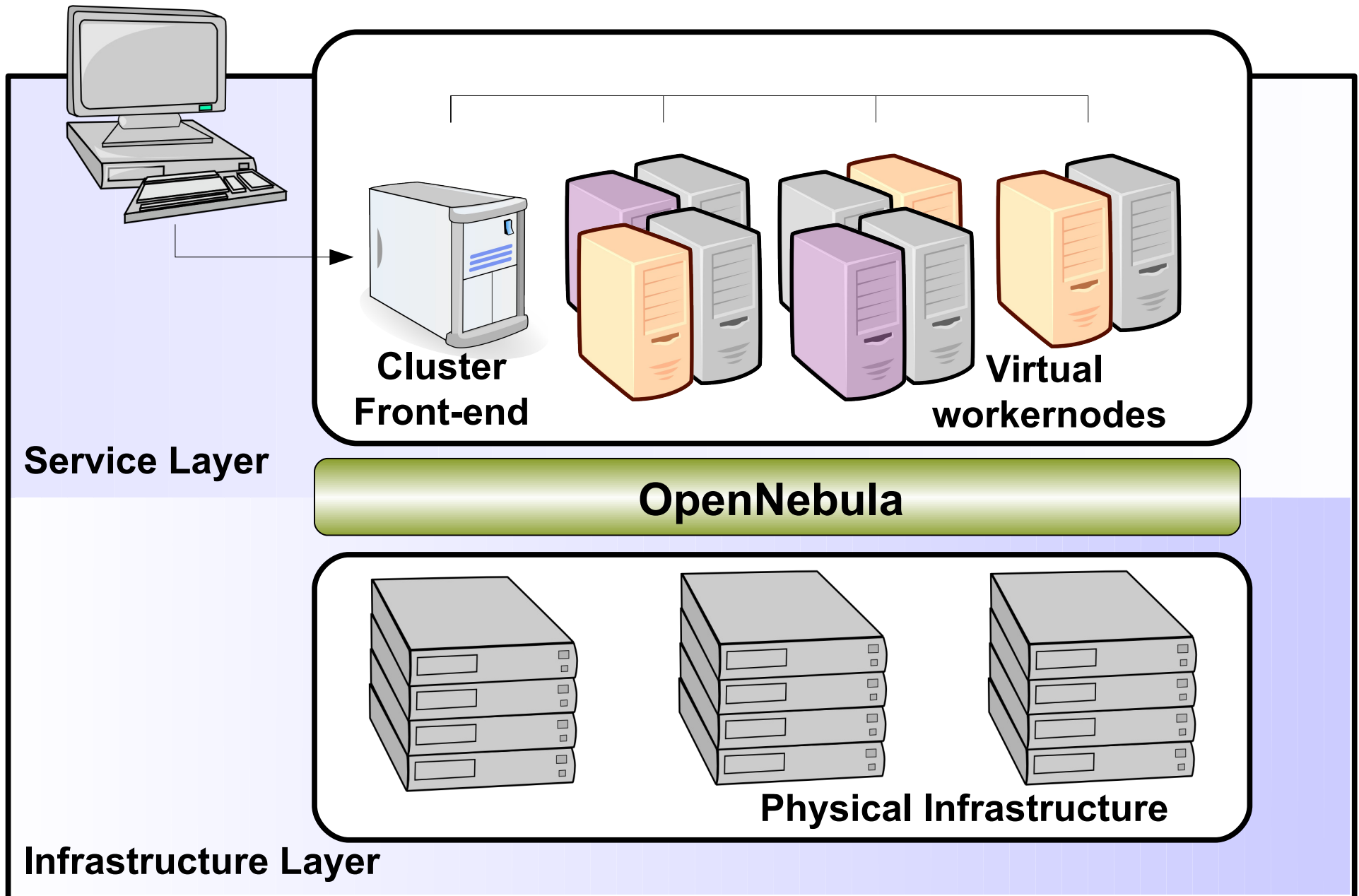


**Application / HW decoupling**

VMs can be provided with a **Cloud-like model!**

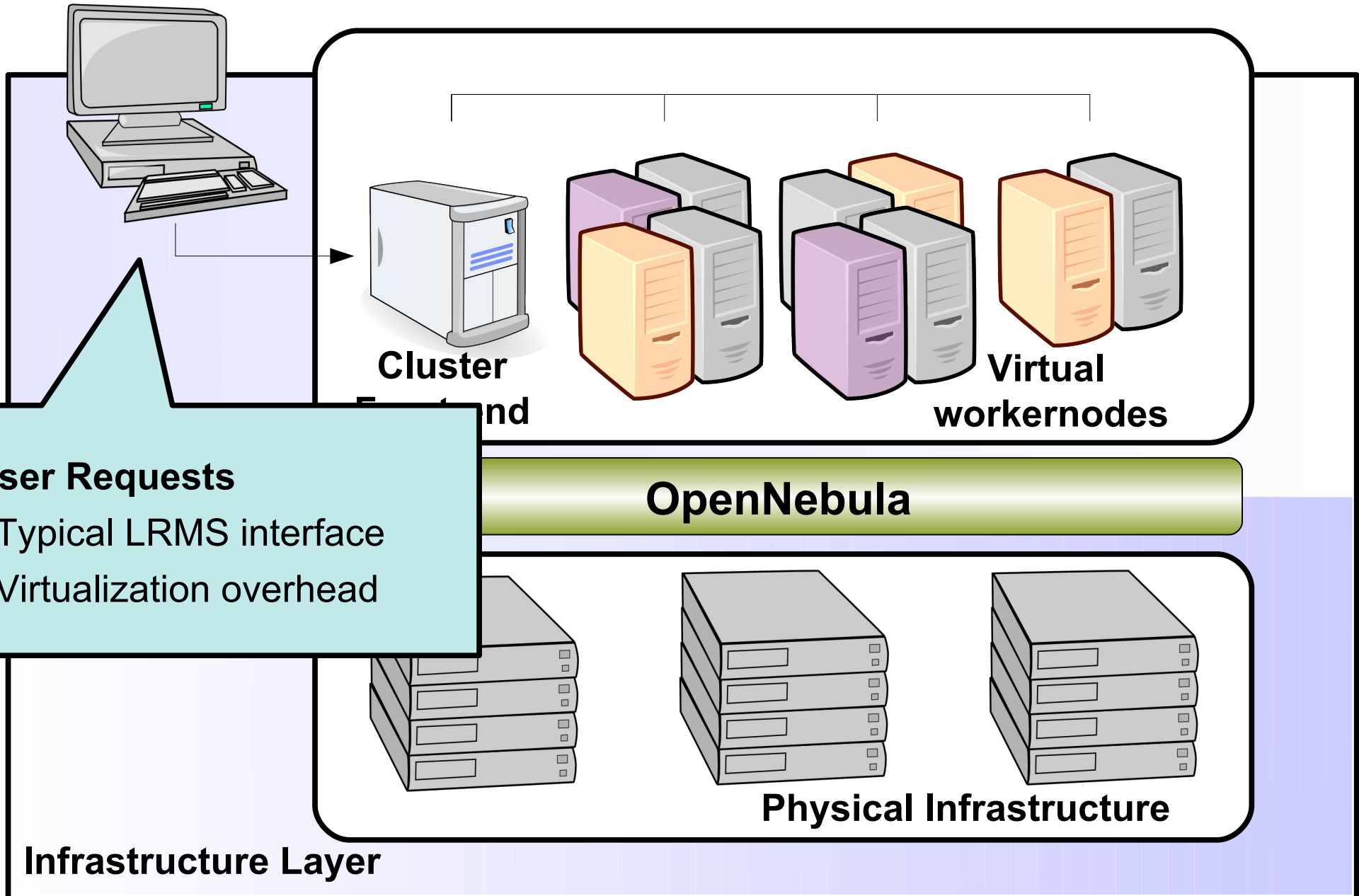
# Grids, Clouds... and Virtual Machines

Cluster users



# Grids, Clouds... and Virtual Machines

Cluster users

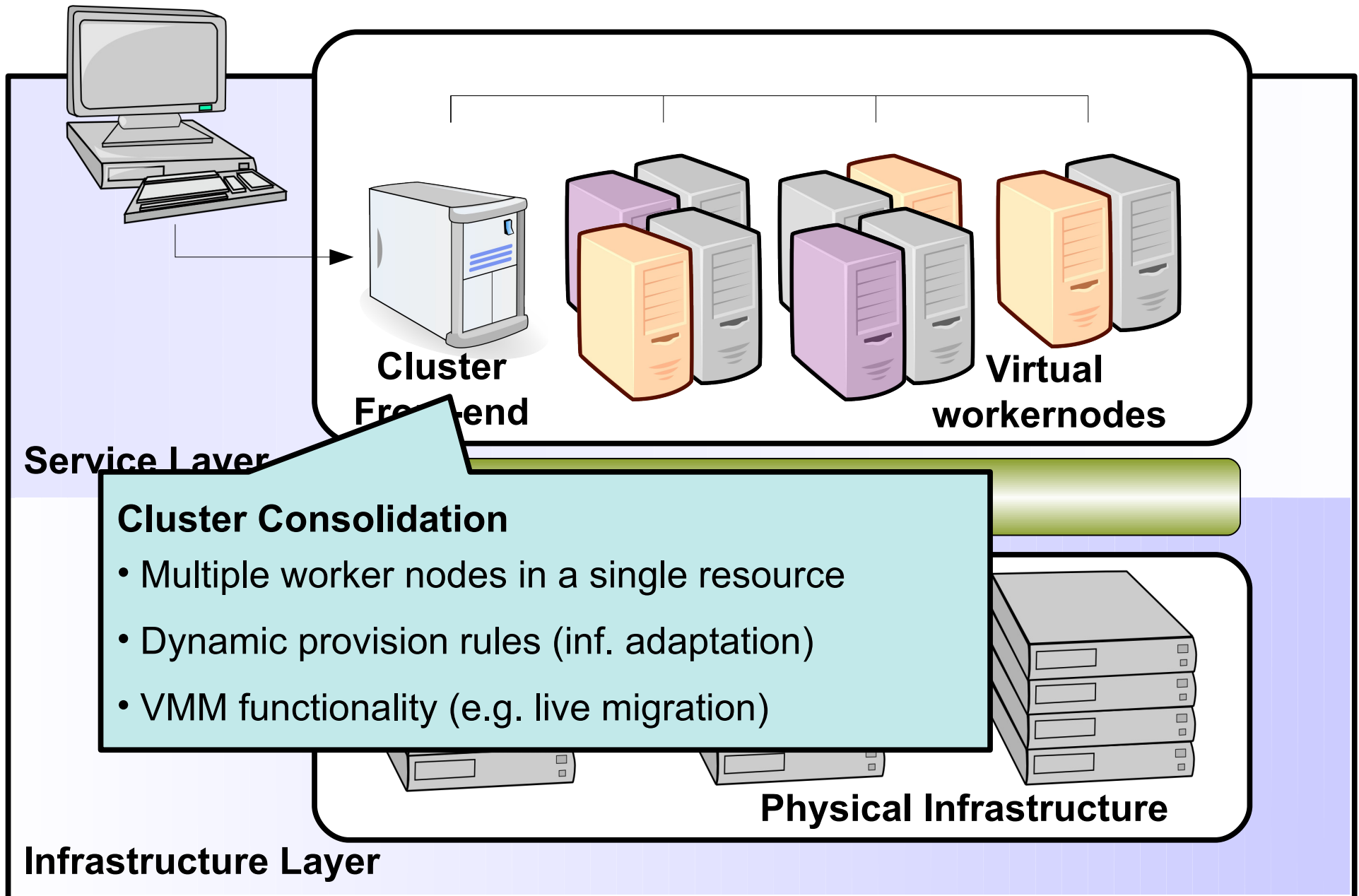


## User Requests

- Typical LRMS interface
- Virtualization overhead

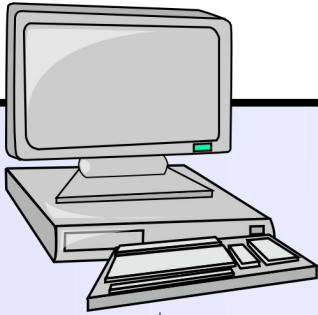
# Grids, Clouds... and Virtual Machines

Cluster users



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Cluster users



## Cluster Partitioning

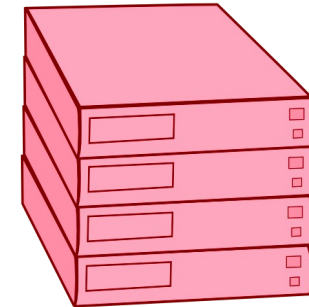
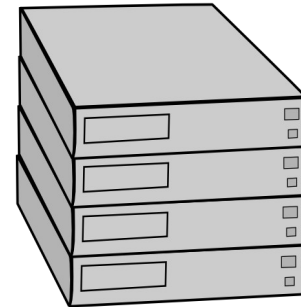
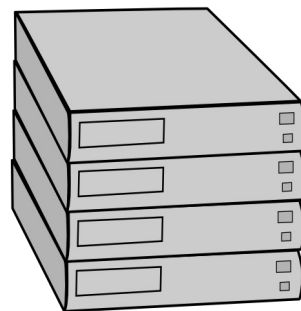
- Performance partitioning (dedicated nodes)
- Isolate cluster workload
- Dedicated HA partitions

Cluster Front-end

Virtual workernodes

Service Layer

OpenNebula

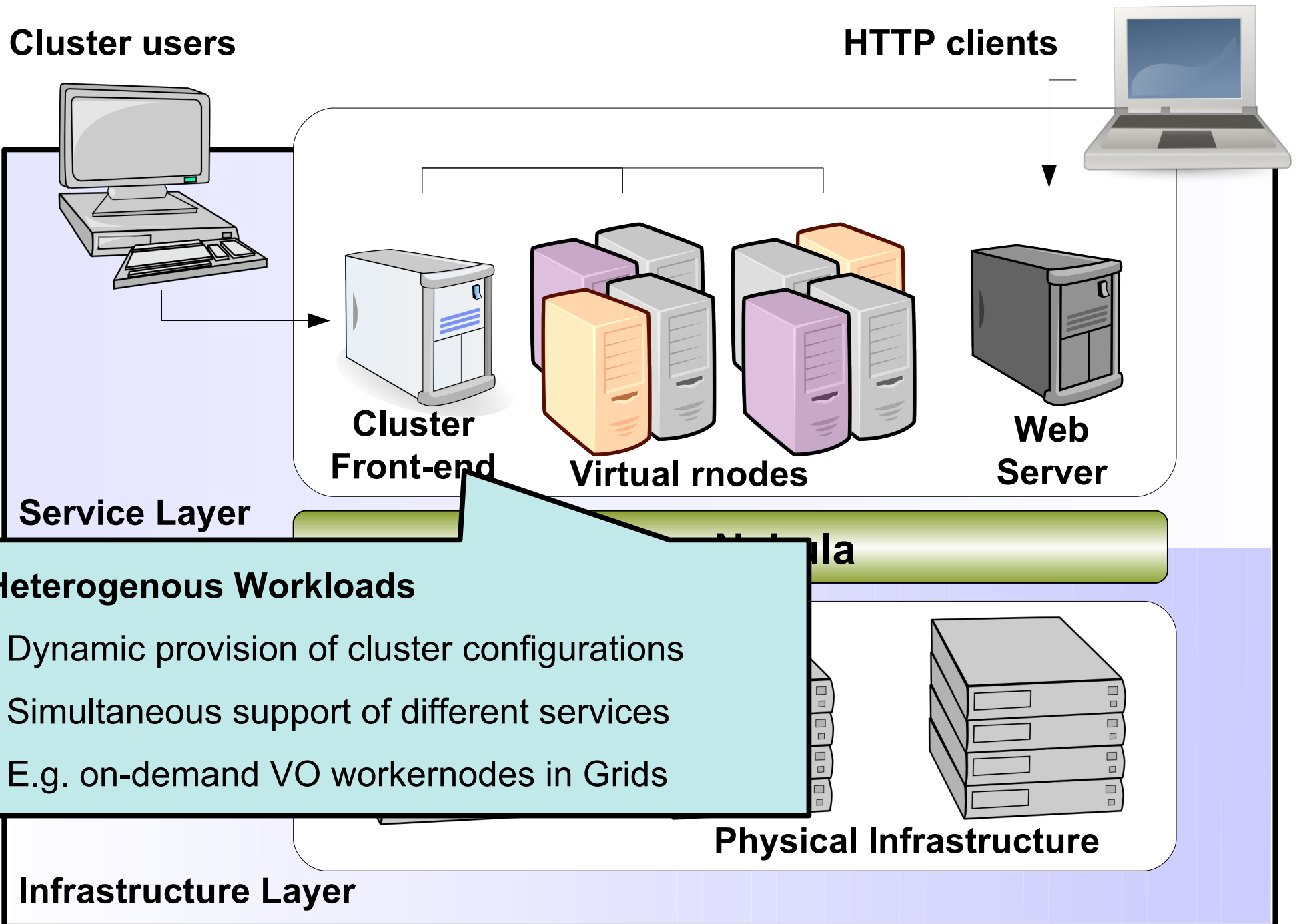


Physical Infrastructure

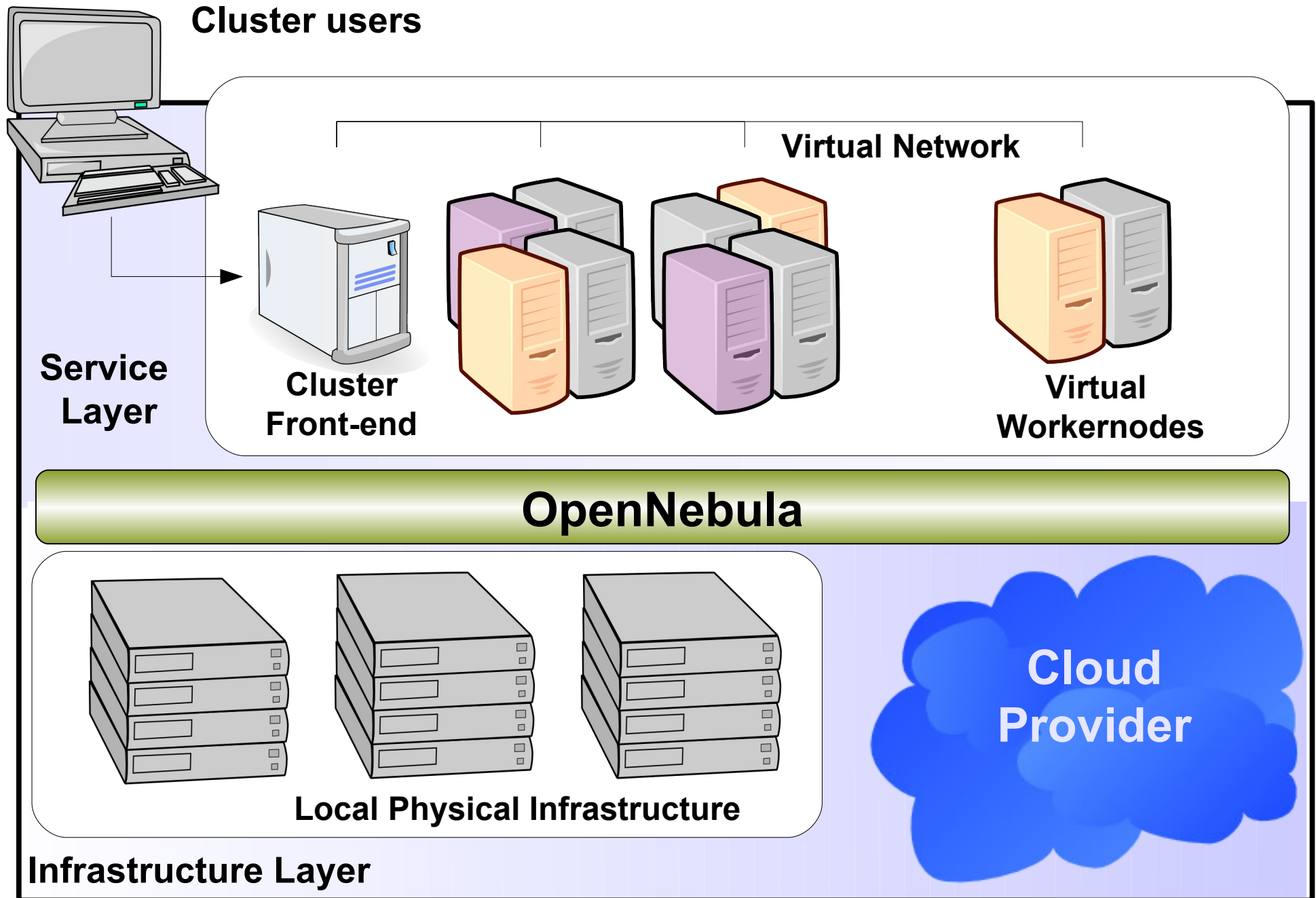
Infrastructure Layer



# Grids, Clouds... and Virtual Machines



# Grids, Clouds... and Virtual Machines



# Building Clouds with OpenNebula: A Grid Computing Perspective

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- Provide an overview of Cloud Computing
- Describe how Clouds can help Grids
- **Experiences using Clouds and Grids**
- Hands on: Using a OpenNebula Cloud

# Grids, Clouds... and Virtual Machines

- **Use VMs as basic building block for Grid Services**

- **Current Trends:**

- **VMs as Job Container**

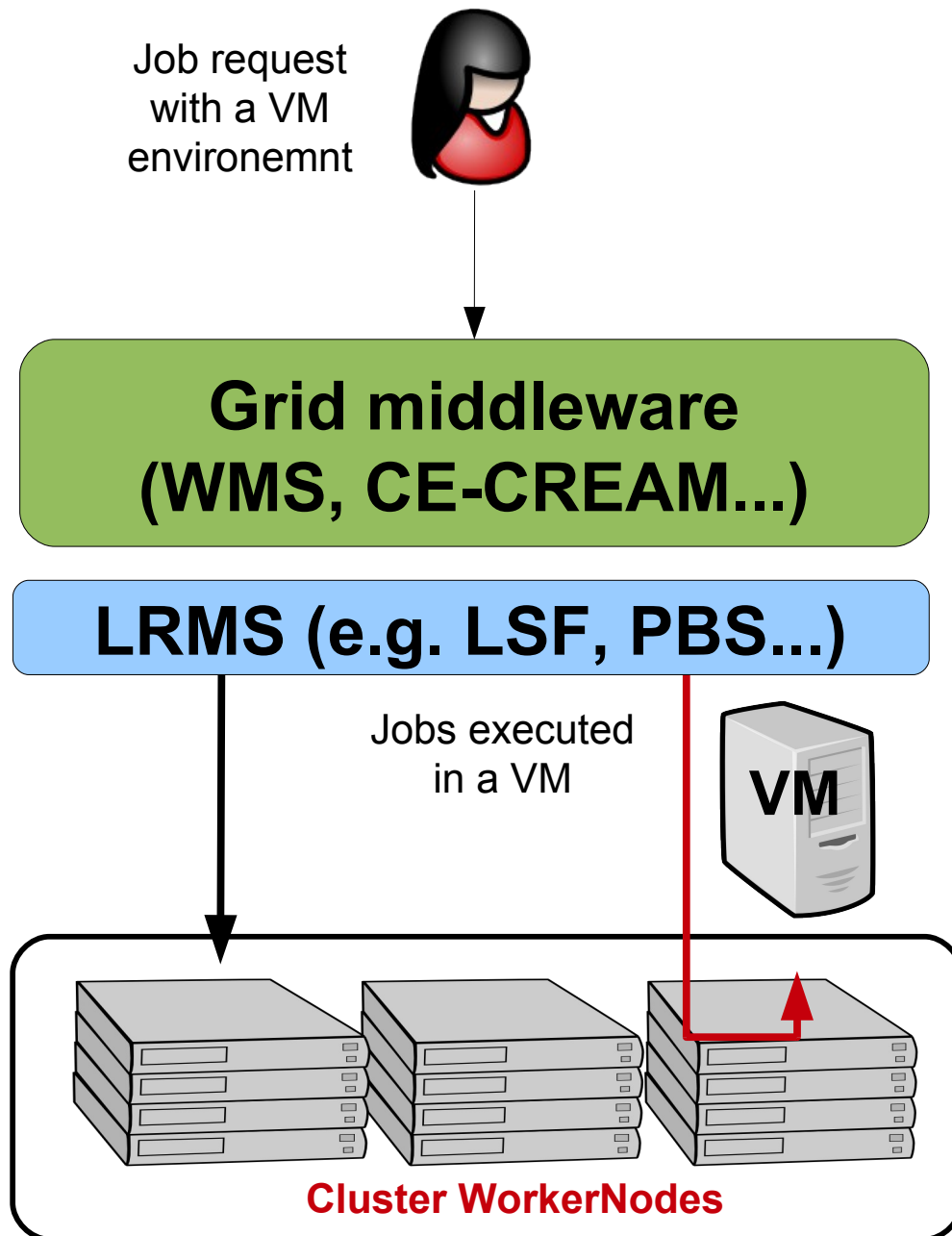
- **VMs as Grid execution service component**

- Deal with heterogeneity
- Simplify & Improve site management
- Give VOs control over the worker-node SW

- **IaaS interfaces for a Grid Site**

- Attract business users
- Support novel execution models

# VM as a Job Container



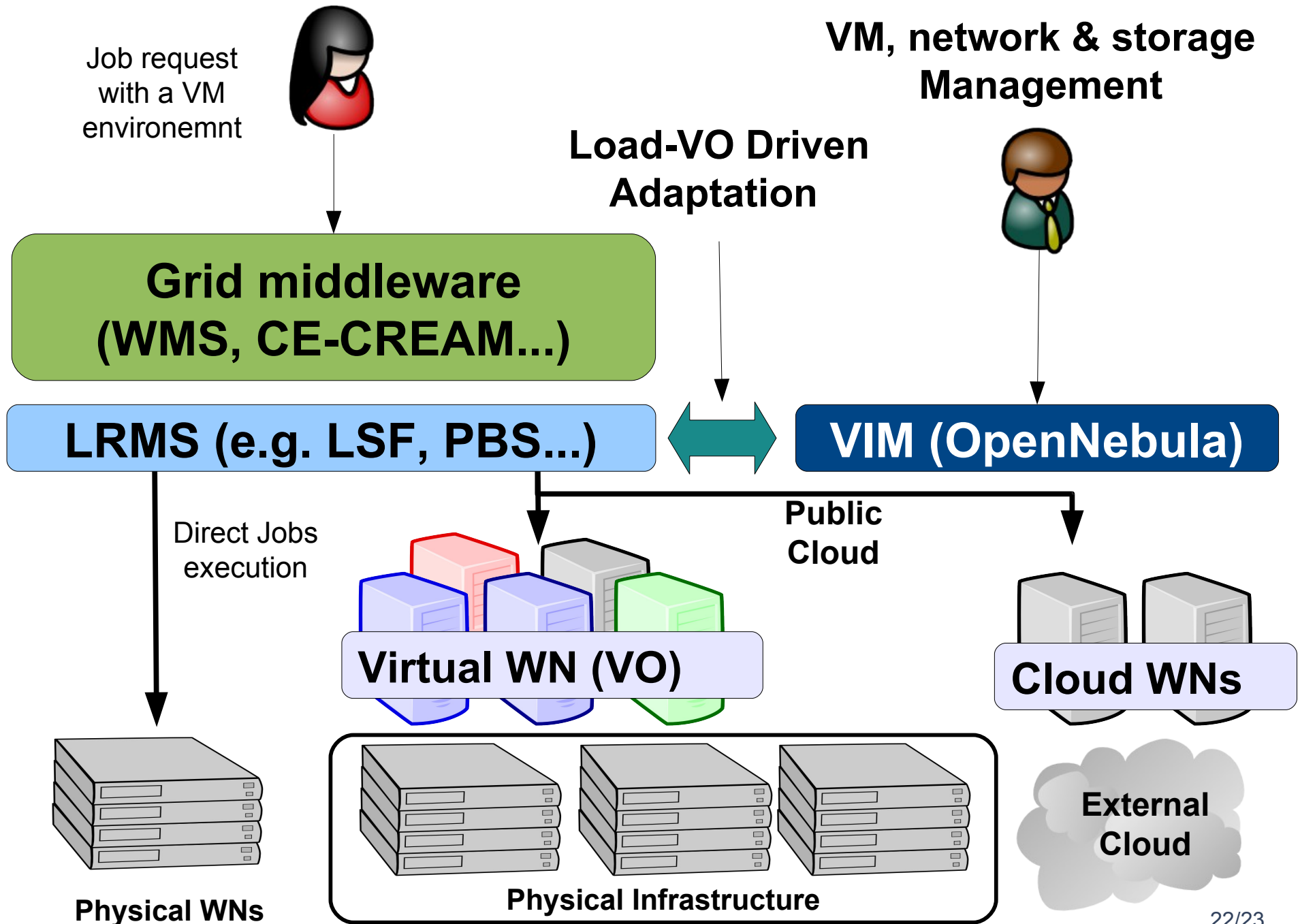
## Features

- Single LRMS-based
- Integrated with Grid MW

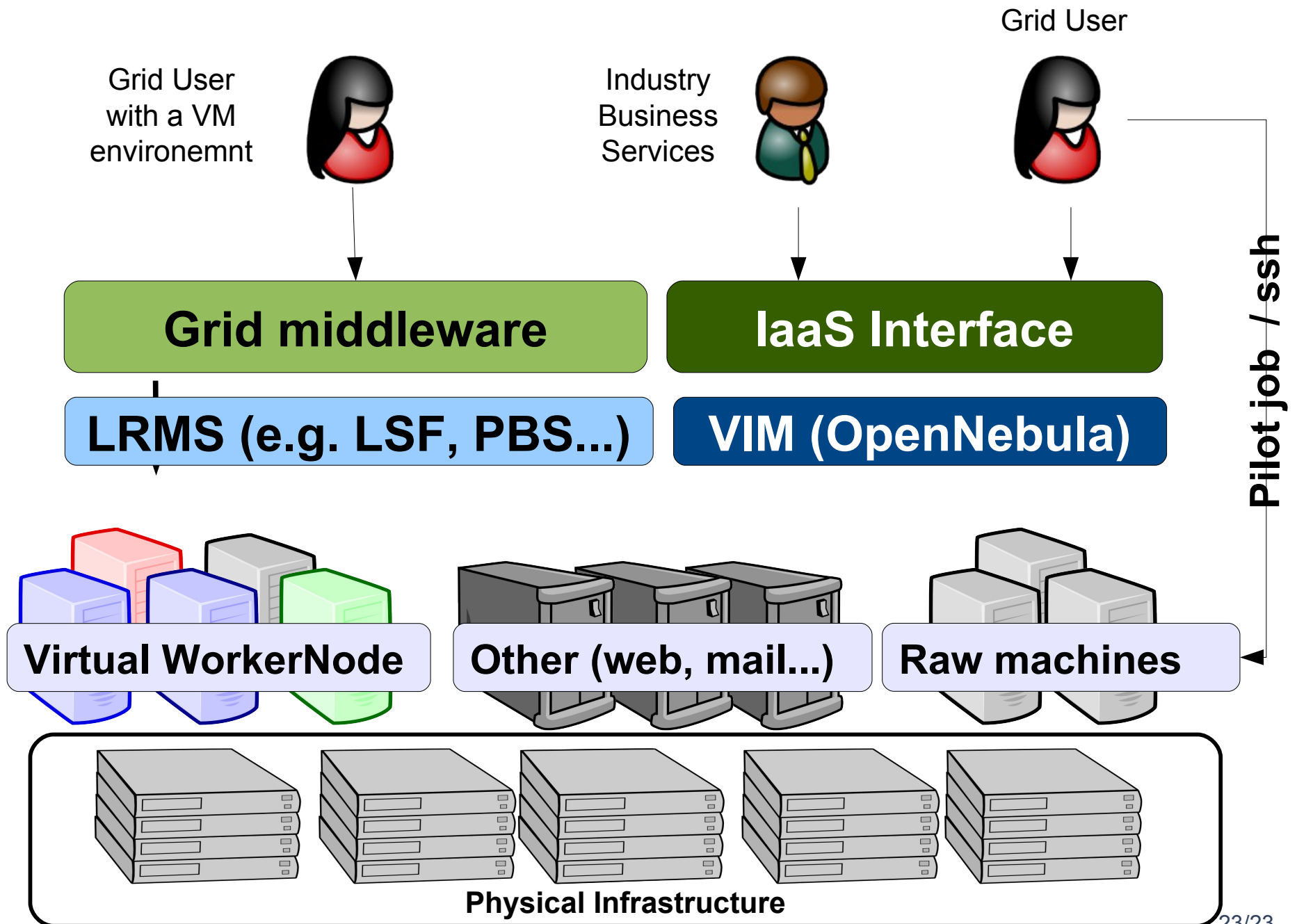
## Drawbacks

- Jobs and VMs are different
- Need to integrate other resources (network, storage...)
- Do not decouple totally infrastructure from the Grid services
- Can not leverage VM features (e.g. Migration...)
- Focused on Job execution

# VM as Grid Service Component



# IaaS Interface for a Site



# OpenNebula in the Grid Arena

- A team at Clemson University and CERN has used OpenNebula to deploy ~ 10,000 VMs on 500 physical hosts running Xen.
- These VMs are used to run batch jobs (submitted via WLG-CE and managed by LSF)
- Used XMLRPC API to add autonomic functionality, and to integrate with CERN's Quattor (<http://www.quattor.org/>)
- Created, and contributed, drivers for using LVM-based disk images.





# OpenNebula in the Grid Arena

- The D-Grid Resource Center Ruhr (DGRZR) has used OpenNebula to manage 247 Blades with a total of 1,972 cores.



- Entire D-Grid software stack is run on VMs. Worker nodes currently managed with OpenNebula, frontend nodes to follow shortly

- The BiG Grid Virtual Machine Working Group (in NIKHEF) did an evaluation of several cloud solutions, and recommended using OpenNebula for managing worker node VMs in BiG Grid.



# OpenNebula in the Grid Arena

- SARA is the Dutch National HighPerformance Computing and e-Science Support Center, and the Dutch supernode in the international Science Grid.
- They offer an HPC cloud that uses OpenNebula. Starting with 128 cores across 16 physical machines running KVM.
- Users use a management console developed at SARA to request a new VM (several templates are provided for them)



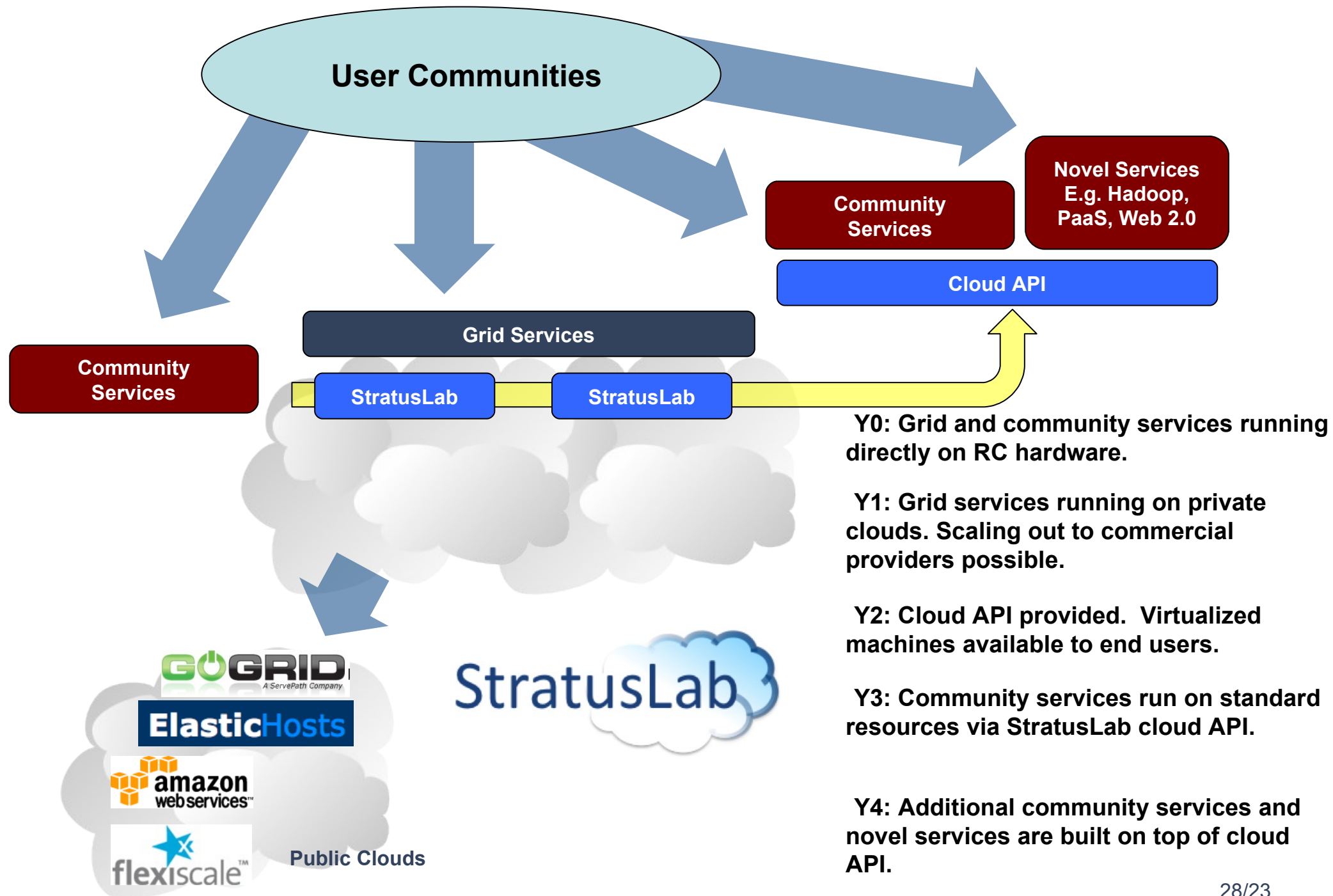
## Vision

- Grid and cloud embody **complementary computing models** that will coexist and cooperate in existing and future e-infrastructures

## Aim

- To produce the **StratusLab Toolkit** open source cloud distribution, bringing **cloud/virtualization innovation to existing Grid infrastructures.**
- **Service Centred Project** driven to support production infrastructures

# The StratusLab Project



# Building Clouds with OpenNebula: A Grid Computing Perspective

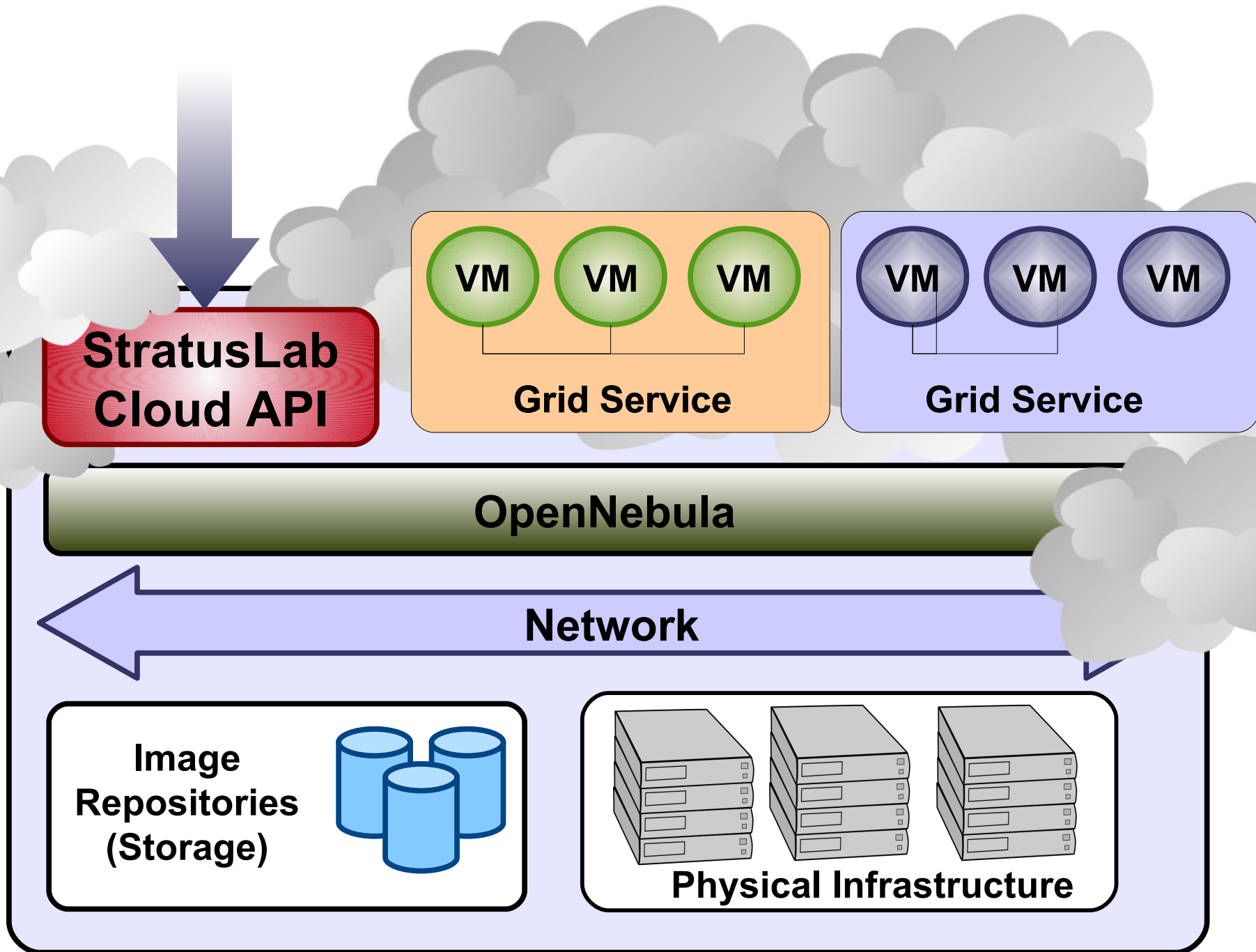
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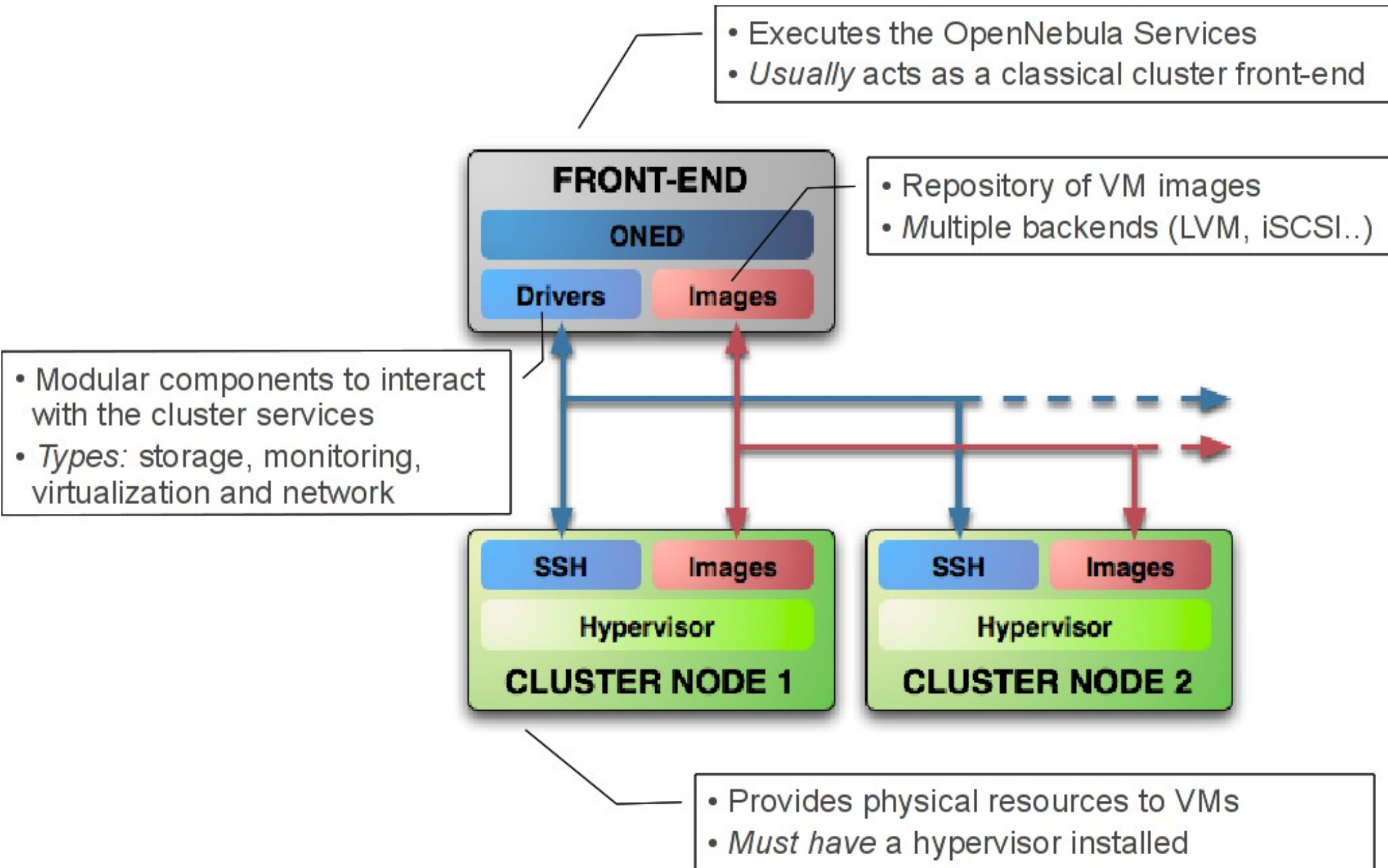


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# The Anatomy of an OpenNebula Cloud



# Overview of Main Components



# Using Virtual Networks and Hosts

- Define VM NICs attached to a given virtual network. The VM will get a NIC with a free MAC in the network

```
#A VM with two interfaces each one in a different vlan
```

```
NIC=[NETWORK="Blue LAN"]
```

```
NIC=[NETWORK="Red LAN"]
```

```
#Ask for a specific IP/MAC of the Red vlan
```

```
NIC=[NETWORK="Red LAN", IP=192.168.0.3]
```

- Prepare the VM to use the IP. Sample scripts to set the IP based on the MAC are provided.

## IP-MAC address correspondence

IP:

10. 0. 1. 2  
↓ ↓ ↓ ↓

MAC: 02: 01: 0A: 00: 01: 02

oned.conf

IP Address

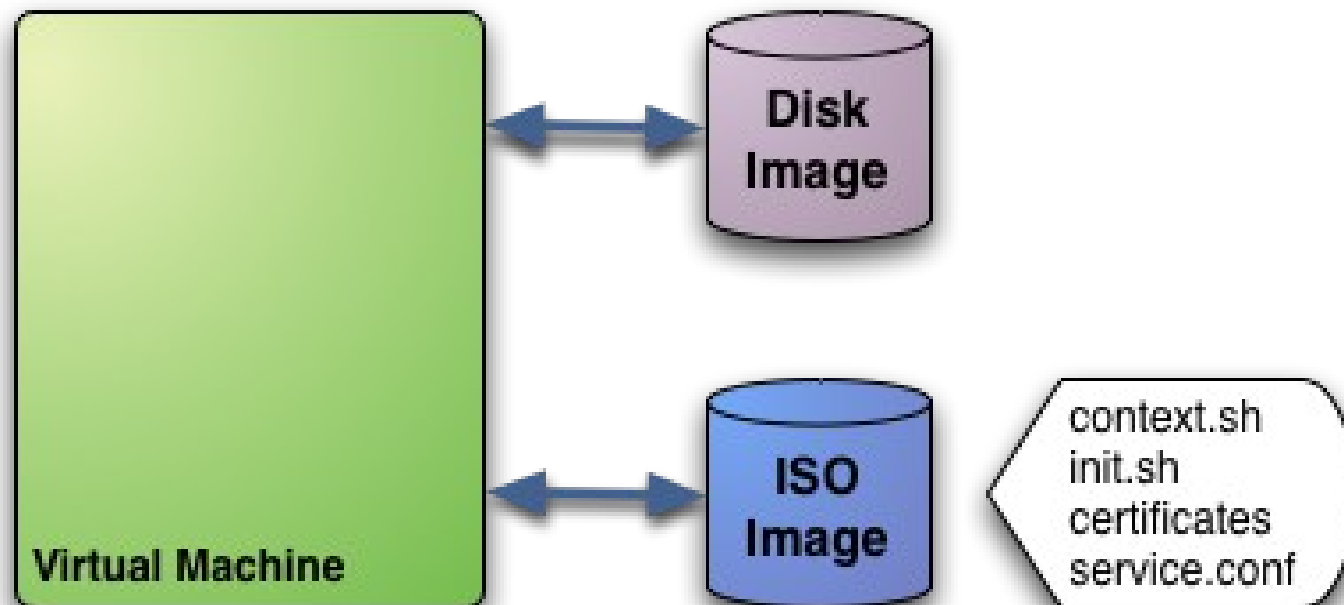


# Defining a Virtual Machine

- A capacity in terms memory and CPU
  - A set of NICs attached to one or more virtual networks
  - A set of disk images, to be “*transferred*” to/from the execution host.
  - A state file (optional) or recovery file, with the memory image of a running VM plus some hypervisor specific information.
- 
- Virtual Machines are defined in a VM template
  - Each VM has an unique ID in OpenNebula the VM\_ID

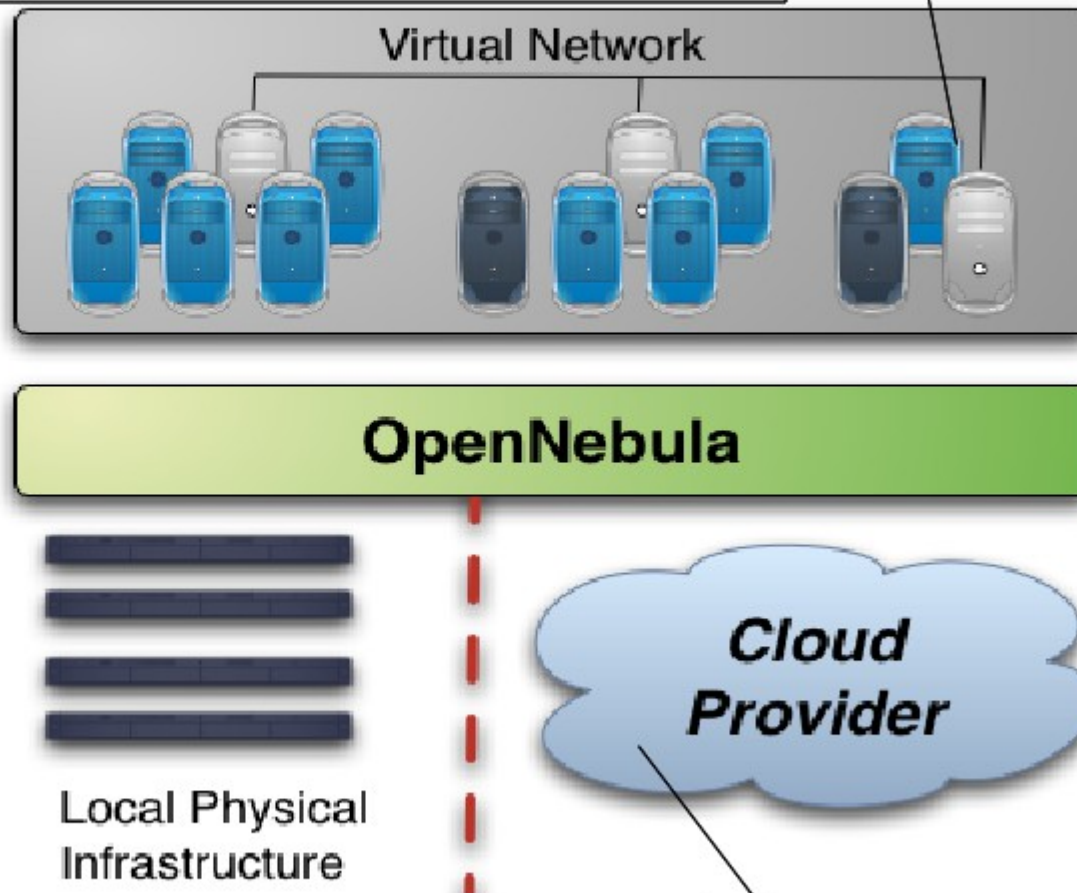
# Context for Virtual Machines

- Custom data to be passed to the VM at boot time
- **Boot Process**
  - Mount an iso image with context data
  - Use context.sh to look for variables
  - Access any file to setup VM services (e.g. ssh keys...)



# Hybrid Cloud Computing

- VMs can be local or remote
- VM connectivity has to be configured, usually VPNs



- External Clouds are like any other host
- Placement constraints

# Using the EC2 Cloud with OpenNebula

- Several accounts or zones can be configured
- The capacity allocated in EC2 can be limited
- VMs must be prepared to be instantiated locally or in the EC2
- The template must provide a description for both instantiation methods.
- The EC2 counterpart of your VM (`AMI_ID`) must be available for the driver account

```
EC2 = [  
  AMI           = "ami_id for this VM",  
  KEYPAIR       = "the keypair to use the instance",  
  AUTHORIZED_PORTS = "ports to access the instance",  
  INSTANCETYPE  = "m1.small...",  
  ELASTICIP     = "the elastic ip for this instance",  
  CLOUD         = "EC2 cloud to use"  
]
```

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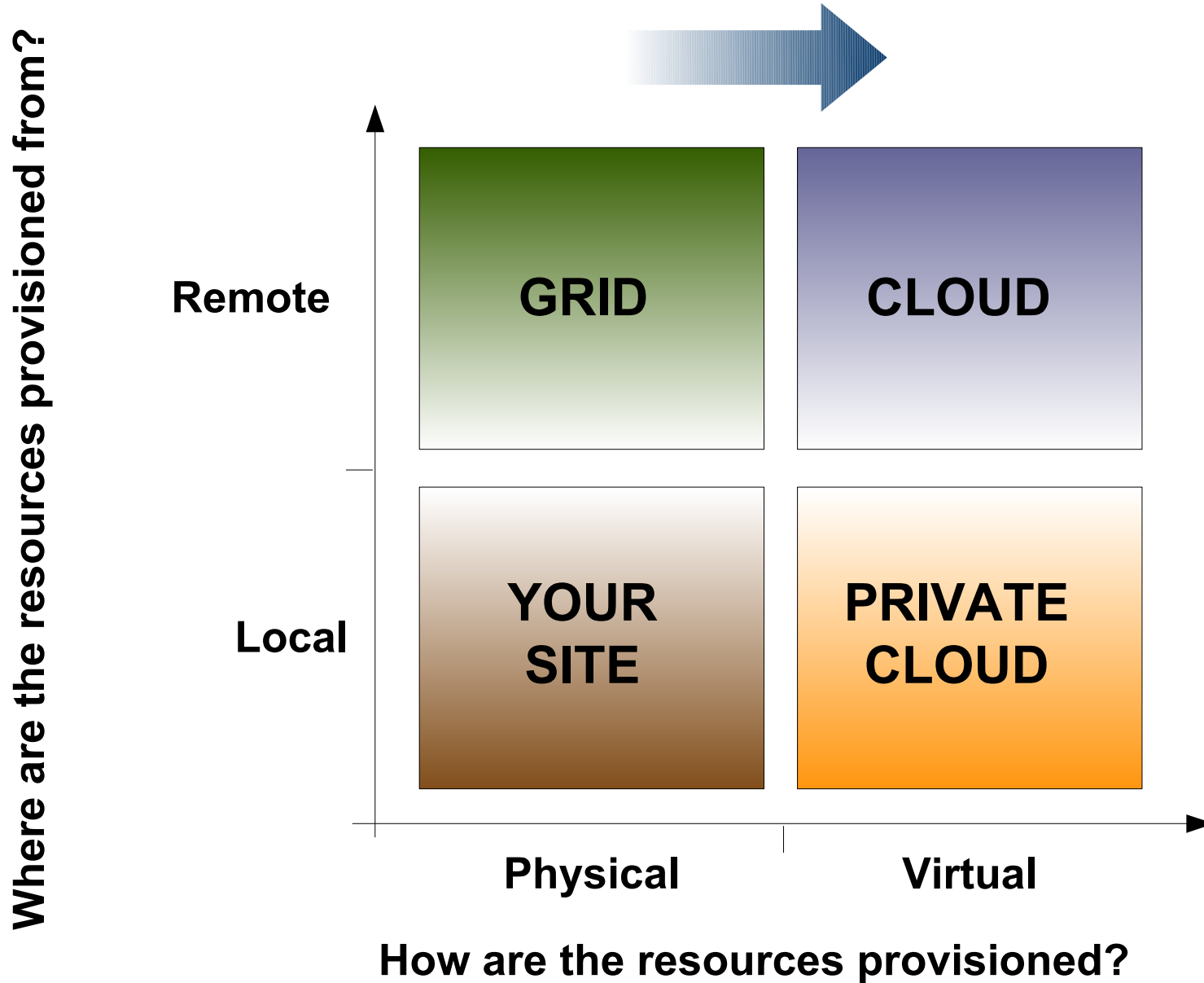
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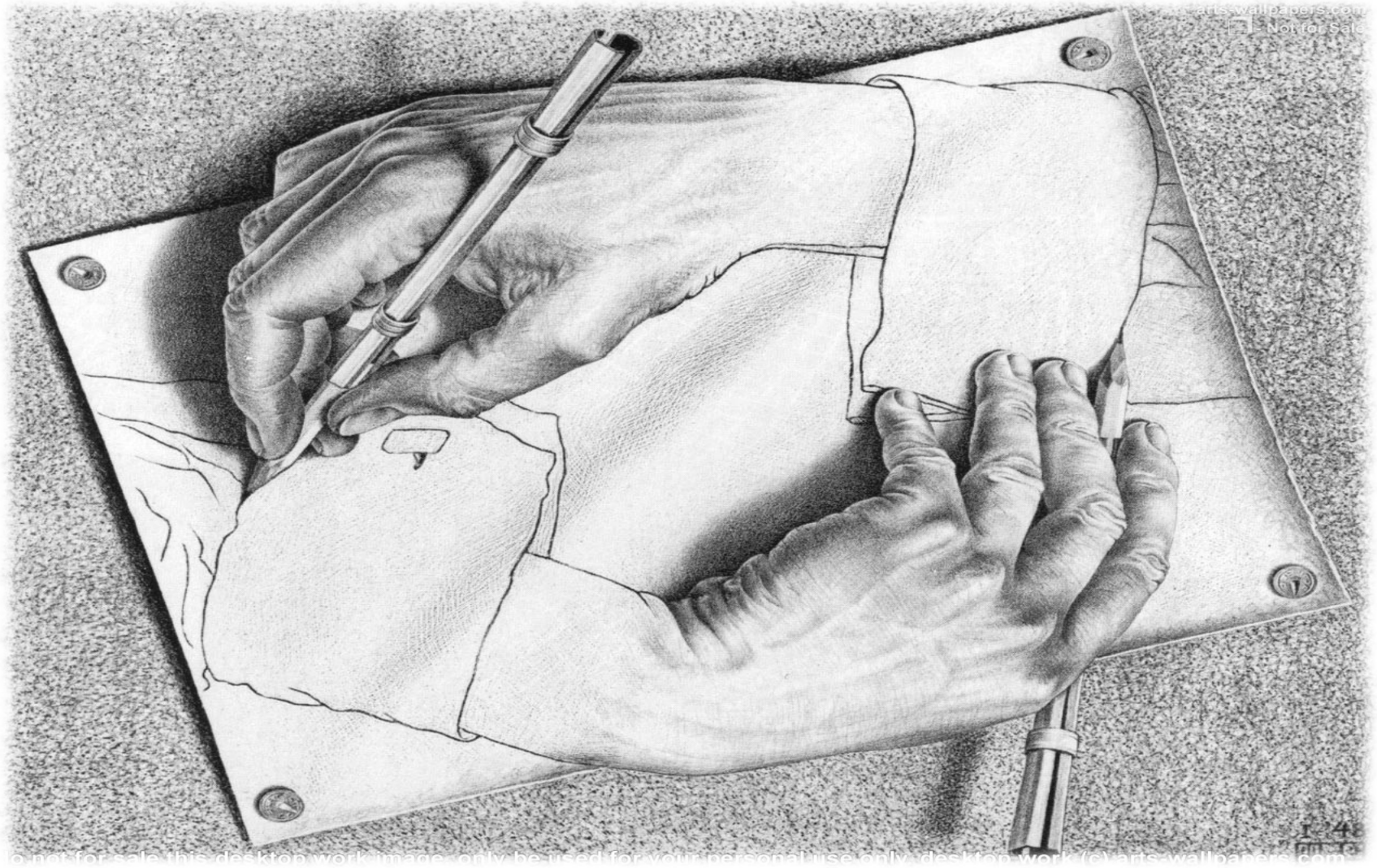
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# Resource Provisioning Models





# THANK YOU FOR YOUR ATTENTION



## QUESTIONS?